EFFECTS OF ATTENTIONAL STRATEGIES, TASK EXPERTISE AND ANXIETY ON COORDINATION OF A DISCRETE MULTI-ARTICULAR ACTION

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The purpose of this study was to determine whether anxiety effects on performance of a discrete multi-articular action could be alleviated by attentional strategies and task expertise. 10 expert and 9 novice male basketball players performed 30 free-throws under both control and anxiety conditions. The dependent variables of interest included shooting performance, reaction time, joint amplitude of the wrist, elbow and shoulder, and coordination variability of the shooting arm using the normalised root mean squared difference technique. A significant main effect for condition was observed for reaction time, indicating the implementation of attentional strategies in both groups. In relation to this observation, no significant main effects for condition were found for shooting performance or any of the kinematic variables. Under conditions of elevated emotions, the allocation of additional attention to the primary shooting task seemed to attenuate the effects of anxiety, regardless of expertise. The findings are harmonious with existing data on attention and anxiety effects on coordination of rhythmical actions. They specifically demonstrated how participants, differing in expertise, used attentional strategies to stabilise performance of a discrete multi-articular action against emotional fluctuations.

KEYWORDS: anxiety, attention, constraint, coordination, expertise, movement variability.

INTRODUCTION:

The issue of anxiety has been a topic of interest for sport scientists (e.g., Janelle, 2002). Avenues of study have included effects of anxiety on joint kinematics (Beuter *et al.*, 1989), movement variability (Higuchi *et al.*, 2002) and stability of coordination dynamics (Monno *et al.*, 2000; Court *et al.*, 2005). Monno *et al.* (2000) found that allocation of attention was an important organismic constraint for stabilising an anti-phase pattern of coordination during a rhythmical bimanual coordination task. Court *et al.* (2005) corroborated these data and observed that participants were able to stabilise preferred patterns of rhythmical bimanual coordination by dedicating additional attentional resources to the task when anxious. They suggested that anxiety acted as a source of behavioural information capable of stabilising coordination through an increase in coupling strength between oscillating limbs in rhythmical task performance. In other words, anxiety acted as an organismic constraint that required individuals to invest additional attentional resources in the task in order to override the intrinsic dynamics of the motor system. However, it is unclear whether attentional resources can be used in the same way to stabilise performance of discrete actions, such as basketball shooting, to negate effects of anxiety on motor system intrinsic dynamics. Key differences between rhythmical and discrete actions have been noted in the movement sciences literature, indicating the need to study effects of organismic and task constraints on stability and variability of movement coordination in both types of tasks (Chow *et al.*, in press).

Within the context of the present study it is important to note the conceptual differences between stability and variability. Motor system stability is enhanced when perturbations are resisted, whereas variability relates to the flexibility of neurobiological systems in achieving a specific task goal (Li *et al.*, 2005). From a dynamical systems perspective, movement variability is considered to be functionally adaptive whereby motor system degrees of freedom interact in a compensatory manner to preserve the outcome of the movement (Davids *et al.*, 2003). To date, very little research has been conducted looking at the effect of anxiety on movement variability (Higuchi *et al.*, 2002). Higuchi *et al.* (2002) found that under conditions of elevated psychological stress, participants exhibited smaller amplitude of movement and reduced variability of spatial kinematic events during a computer-simulated batting task. The authors proposed that anxiety caused participants to freeze motor system degrees of freedom to achieve the task goal.

The purpose of this study was to determine whether successful outcomes and joint kinematics could be preserved under conditions of anxiety by participants investing additional attentional resources during performance of a discrete shooting task. Furthermore, Janelle (2002) argued that experts may be more capable of regulating emotional fluctuations than non-expert performers. However, it is not known whether performance expertise plays a mediating role in the capacity to stabilise a discrete pattern of movement coordination against perturbation from emotional fluctuations. Therefore, a secondary purpose of this study of discrete action performance was to identify variations in attentional strategies between expert and novice performers to stabilise task accomplishment.

METHODS:

10 expert (mean (± SD) age of 21.5 ± 2.1 years) and 10 novice (mean (± SD) age of 20.2 ± 0.9 years) male basketball players provided voluntary informed consent to participate in the study. Each participant was categorised as either an expert or novice using a performance pre-test (adapted from Vickers, 1996) and a questionnaire indicating previous basketball experience. Prior to data collection, all procedures were approved by the University's ethics committee. Each participant completed 30 shots from a distance of 4.25 metres (equating to the free-throw line) under two conditions: a control condition and an anxiety condition. A counterbalanced design was implemented to minimise potential order effects. The two performance conditions were separated by approximately one week and occurred at the same time of day to reduce possible diurnal variation effects. Anxiety was induced by way of a financial incentive and social evaluation effects through the presence of an independent assessor. Measures of cognitive anxiety, somatic anxiety and self confidence were taken for each condition before and after the completion of the 30 performance trials using the modified competitive state anxiety inventory (CSAI-2: Jones and Swain, 1992). The anxiety manipulation was deemed successful because the expert and novice participants reported being significantly more anxious during the anxiety condition than during the control condition ($p < 0.05$). Importantly, the anxiety manipulation was also maintained throughout the 30 trials for both conditions because there were no significant differences in CSAI-2 scores for all subscales between the pre test and post test ($p > 0.05$).

For each of the 30 trials shooting performance was assessed using a 1 - 8 scoring scale (adapted from Landin *et al.*, 1993). A score of 1, for example, signified missing the ring and backboard completely whereas a score of 8 was recorded when the ball entered the basket without contacting the hoop rim. Kinematic data were collected using an eight camera motion analysis system sampling at a frequency of 200 Hz (Motion Analysis Corporation, Santa Rosa, CA). Twenty five 12.7 mm retro-reflective markers were attached to appropriate anatomical landmarks and used to define 4 body segments: the trunk, upper arm, lower arm and hand. A SONY TRV950E digital camera, sampling at 25 Hz, was linked to the motion analysis system to identify the beginning and end of each performance trial. The beginning of each performance trial was defined as the first upward movement of the ball whereas the end was determined by peak flexion of the wrist. The shutter speeds of both the motion capture system and SONY digital camera were set to 1/1000s. Finally, the attentional demands for each condition were measured using a probe reaction time task with a buzzer and voice-activated switch inputted as analogue signals into the motion capture system. The buzzer was initiated at an instant between movement initiation and ball release, and participants were instructed to react as quickly as possible by shouting the word 'shot'. The analogue signals were sampled at a frequency of 1000 Hz and reaction time was calculated as the time difference in milliseconds between the two voltage offsets.

The raw three-dimensional coordinate data were filtered using a zero lag 4^{th} order Butterworth filter with the cut-off frequency selected at 5 Hz. The three-dimensional joint coordinate system angles for the wrist, elbow and shoulder joints were then generated using

Visual 3D version 3.79 (C-Motion Inc., MD, USA). Each trial was cropped using the beginning and end points identified from the SONY digital camera and subsequently interpolated to 101 data points using a cubic spline technique. The dependent variables included shooting performance score, reaction time, joint amplitude (RoM) of the wrist, elbow and shoulder, and coordination variability of the shooting arm using the normalised root mean squared difference technique (NoRMS) proposed by Sidaway *et al.* (1995). Coordination variability was calculated for the following joint couplings: wrist flexion/elbow extension, elbow extension/shoulder extension and wrist flexion/shoulder extension. Each dependent variable was subjected to a 2 (expertise) * 2 (condition) analysis of variance (ANOVA) with expertise as the between-subjects factor and condition as the within-subjects factor. It should be noted that due to a motion tracking problem during data collection, one novice participant was excluded from the analysis. All assumptions underpinning use of parametric tests were tested for and verified. An alpha level of 0.05 was selected to compromise between committing a type I and type II error. Inferential statistics were also supplemented with measures of effect size (η^2) to quantify the meaningfulness of the differences. Eta squared (η^2) is a measure of the proportion of the total variance that is explained by the treatment effects.

RESULTS:

The mean (± SD) values for each dependent variable as a function of both expertise and anxiety condition are presented in Table 1. There were no significant expertise * condition interactions for any of the dependent variables ($p > 0.05$, $\eta^2 < 0.149$). There were significant main effects for skill level for shooting performance ($p = 0.0001$, $\eta^2 = 0.671$), ranges of motion for the wrist ($p = 0.0001$, $\eta^2 = 0.525$) and elbow ($p = 0.002$, $\eta^2 = 0.441$) and measures of continuous coordination variability for all three joint couplings: wrist-elbow ($p = 0.003$, $\eta^2 = 0.418$), elbow-shoulder ($p = 0.015$, $\eta^2 = 0.299$) and wrist-shoulder ($p = 0.002$, $\eta^2 = 0.423$). Specifically, experts performed markedly better in both the control and anxiety conditions, and exhibited greater amplitude of motion for the wrist and elbow joints together with smaller movement variability for all three joint couplings. There was a significant main effect for condition for reaction time ($p = 0.006$, $\eta^2 = 0.364$), with post-hoc tests revealing that both expert and novice performers invested significantly more attention during the anxiety condition than the control condition ($p < 0.05$, $\eta^2 = 0.339 - 0.385$). No significant main effects for condition were observed for any of the other dependent variables ($p > 0.05$, $\eta^2 < 0.13$).

Table 1 Mean (± SD) values for each dependent variable of interest as a function of both skill level and anxiety condition

	Novices		Experts	
Dependent Variable of Interest	Control	Anxiety	Control	Anxiety
Shooting Performance (pts)	137 ± 15	136 ± 20	178 ± 16	176 ± 15
Reaction Time (ms)	472 ± 88	532 ± 101	426 ± 49	470 ± 84
Wrist RoM (°)	89 ± 17	87 ± 17	120 ± 15	119 ± 15
Elbow RoM (°)	83 ± 11	82 ± 12	102 ± 10	101 ± 14
Shoulder RoM (°)	88 ± 23	89 ± 25	100 ± 11	100 ±11
NoRMS for Wrist-Elbow Coupling (°)	10.3 ± 4.0	9.7 ± 2.5	6.00 ± 2.5	5.8 ± 2.0
NoRMS for Elbow-Shoulder Coupling (°)	7.9 ± 3.0	7.0 ± 1.5	5.40 ± 2.4	4.9 ± 1.5
NoRMS for Wrist-Shoulder Coupling (°)	10.4 ± 4.2	8.9 ± 2.1	5.77 ± 1.6	5.9 ± 1.6

DISCUSSION:

The purpose of this study was to determine whether anxiety effects on performance of a discrete shooting action could be mediated by attentional strategies in expert and novice basketball players. As expected, experts performed significantly better than novices for both control and anxiety conditions. Experts also exhibited greater ranges of motion about the wrist and elbow joints, coupled with a smaller magnitude of coordination variability for all three joint couplings. No significant differences for condition were observed for shooting performance or joint kinematics in the current study. The lack of change in joint kinematics between control and anxiety conditions in the shooting task, contrasts with previous work by Higuchi *et al.* (2003) who reported decreased joint amplitude and reduced movement variability under conditions of anxiety during a computer-simulated batting task. The significant main effect for reaction time by condition indicated how the attentional strategies deployed by both groups differed in the treatment and control conditions. The lack of an interaction effect for reaction time by expertise level showed clearly that both experts and novices were able to invest additional attentional resources when anxious to stabilise performance against emotional fluctuations caused by financial incentives and social evaluation. This universal human response to performance perturbations countered previous suggestions that experts may be more capable of regulating emotional fluctuations than non-expert performers (Janelle, 2002). The results of this study on discrete actions corroborate previous work on the allocation of attentional resources to stabilise motor system intrinsic dynamics in performance of rhythmical coordination tasks (Monno *et al.*, 2000; Court *et al.*, 2005). These data on discrete movement performance are consistent with the arguments of Court *et al.* (2005) who suggested that anxiety caused participants to invest additional effort to override the intrinsic dynamics of the human motor system. The data suggest that the allocation of attention is an integral strategy for stabilisation of both rhythmical and discrete coordination patterns against emotional fluctuations (Monno *et al.*, 2000; Court *et al.*, 2005).

CONCLUSION:

Findings of this study suggested that expert and novice performers were able to maintain performance and attenuate effects of anxiety by investing additional attentional resources to performance of a discrete action. Further research is needed to clarify the role of organismic constraints and individual intrinsic dynamics on performance of multi-articular discrete and rhythmical movements.

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